

SHORT COMMUNICATION

***PARDOSA MILVINA* (ARANEAE, LYCOSIDAE) SPIDERLING MOVEMENT IN THE PRESENCE OF CONSPECIFIC AND HETEROSPECIFIC SILK AND EXCRETA**

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ABSTRACT. Adult females of the wolf spider *Pardosa milvina* (Hentz 1844) are known to show adaptive antipredator responses in the presence of chemical cues (silk and excreta) from the larger co-occurring wolf spider *Hogna helluo* (Walckenaer 1837). We tested if the presence of *H. helluo* cues affected *P. milvina* spiderling dismounts from their mothers. Immediately after females opened their egg sacs, we counted offspring and placed spiderling-carrying females on one of three experimental substrates: 1) container previously occupied for 24 h by an adult conspecific female, 2) container previously occupied for 24 h by a juvenile *H. helluo* equal in mass to an adult *P. milvina*, or 3) a control container devoid of either cue. We then measured the proportion of spiderlings that dismounted from their mothers over a six-day period. Spiderling dismounts peaked by day three, after which spiderlings tended to return to their mother. During day one, significantly fewer spiderlings were dismounted from the mother in containers previously occupied by a juvenile *H. helluo* compared to other treatments. There was no significant difference in dismounts among treatments during days 2–6. Since spiderlings were maximally dismounted by day three, we suggest that spiderlings may tend to disperse into areas with fewer *H. helluo*.

Keywords: Spiderlings, lycosid, dispersal, chemical cue, *Hogna helluo*

The wolf spider *Pardosa milvina* (Hentz 1844) and its larger intraguild predator, *Hogna helluo* (Walckenaer 1837) are common throughout agricultural systems in the Midwestern United States (Marshall & Rypstra 1999). Recent studies show that predator-prey interactions among these species are mediated in part through each other's silk draglines and excreta (Persons & Rypstra 2000; Persons et al. 2001). Adult female *P. milvina* respond to chemical cues (silk and excreta) from adult and juvenile *H. helluo* with a suite of antipredator behaviors including substratum avoidance, reduced activity and vertical movement (Persons et al. 2001, 2002; Persons & Rypstra 2001). In contrast, adult female *P. milvina* are unresponsive to conspecific female silk and excreta (Persons et al. 2001, 2002).

Female wolf spiders typically carry their egg sac by attaching it to their spinnerets for a period of several days to more than two months and after opening the egg sac, continue to transport spiderlings on their dorsum for a period of several days to a week or more (Fujii 1976). Spiderlings then disperse primarily via asynchronous dismounting from their mother as she moves through the environment (Fujii 1976) and secondarily via aerial dispersal (Glick 1939; Richter 1970). Juveniles may also periodically dismount and remount their moth-

ers prior to permanent dispersal to drink or reposition themselves for more efficient transport (Eason 1964; Higashi & Rovner 1975).

Pardosa milvina spiderlings may benefit substantially by dismounting their mother when in microhabitats that are devoid of *H. helluo* and their associated chemical cues. Although predator-induced reductions in activity increase survival of *P. milvina* when in the presence of a live *H. helluo* (Persons et al. 2001, 2002; Barnes et al. 2002), these defensive behaviors are costly and contribute to reduced foraging and reproductive success (Persons et al. 2002). Also, under some circumstances, *H. helluo* are attracted to substrates previously occupied by adult female *P. milvina* (Persons & Rypstra 2000) which may further increase predation risk to *P. milvina* spiderlings. Here we tested if the presence of silk and excreta from juvenile *H. helluo* significantly affected the timing of juvenile *P. milvina* dismounts from their mothers.

Sixty-eight mated adult female *P. milvina* were field caught in late May and early June, 2000 within soybean fields on Susquehanna University property adjacent to campus (Selinsgrove, Snyder County, Pennsylvania). All field-collected females were either carrying egg sacs or produced them shortly after being caught. Spiders were individually main-

tained with their egg sacs in white plastic containers with transparent lids (9 cm d, 7 cm h). A small vial lid was placed on the bottom of the container with a few drops of water to serve as a source of moisture and humidity. All spiders were kept at room temperature (23–25 °C) with a 13L:11D photoperiod. Females were given constant access to fruit flies (*Drosophila melanogaster* (Meigen 1830) as a food source and checked daily for spiderling emergence from the egg sac. Because filial or sibling cannibalism is possible among lycosids, we chose to count spiderlings immediately after egg sac emergence to insure an accurate measure of clutch size. After emergence, spiderlings were gently removed from the mother with a soft-bristled paintbrush, counted, and allowed to climb back on their mother. The females with offspring were then randomly assigned to one of three substrate treatments: 1) a container that previously held a juvenile *H. helluo* for 24 h that was equal in mass to an adult female *P. milvina* ($n = 25$); 2) a container that previously held an adult conspecific female *P. milvina* (without an egg sac), ($n = 22$) for 24 h; or, 3) a blank control container devoid of either cue ($n = 21$). *Pardosa milvina* and *H. helluo* used for generating chemical cues were maintained on an ad libitum diet of fruit flies (*D. melanogaster*) prior to being placed in their respective treatment containers. *Hogna helluo* and *P. milvina* were not fed during the time they were used to deposit silk and excreta nor were test *P. milvina* allowed to feed during the trial period. The deposited silk and excreta used as test substrates was not renewed for the duration of the experiment. Female test spiders were initially checked 24 h after being placed on their respective substrate treatments and again every 24 h afterwards for six consecutive days. All *P. milvina* with spiderlings were provided with a small inverted vial cap filled with water during the entire test period. The total number and proportion of spiderlings that had dismounted from their mother was recorded for each replicate. Only a spiderling that had no direct physical contact with its mother was considered dismounted.

Egg sac clutch sizes of *P. milvina* for all treatments varied between 1–101 spiderlings (mean = $31.8 \pm$ S.E. 2.18 offspring; median = 30.5 offspring). Therefore we used the proportion of dismounted spiderlings/egg sac as the dependent variable in our analysis. We angular transformed our proportions to conform to assumptions of normality and performed a repeated-measures two-way ANOVA with chemical cue treatment (fixed effect) and day (random effect) as factors (as in Sih & McCarthy 2002).

Peak spiderling dismounts occurred three days post-emergence (mean 78.3% for all treatments combined)(Fig. 1). By day six of post-emergence, the mean proportion of dismounted spiderlings re-

turned to similar levels observed during the first day. Substrate type had a significant effect on spiderling dismounts ($F_{2,65} = 3.69$; $P = 0.0301$). There was also a significant day effect ($F_{5,65} = 22.22$; $P < 0.0001$). However, there was no significant day by treatment interaction ($F_{5,2} = 1.22$; $P = 0.276$). To better understand dismounting patterns across chemical cue treatments but within days, we performed six *a posteriori* multiple comparison tests (Tukey test for unequal sample sizes) for ANOVAs as described by Zar (1984).

Based on the results of the Tukey tests, significant substrate effects were attributable solely to differences in spiderling dismounts during the first day of emergence. Females placed in containers with *H. helluo* chemical cues had an average of only 28% (mean $8.76 \pm$ S.E. 2.36 spiderlings) of their clutch dismounted by day one compared to 41% (mean $13.23 \pm$ S.E. 3.20 spiderlings) and 55% ($13.71 \pm$ S.E. 2.44 spiderlings) for the *P. milvina* and control treatments respectively. During the first day of emergence, a significantly lower proportion of spiderlings dismounted in the *H. helluo* cue treatment than either the *P. milvina* treatment or blank control. However, the blank control and *P. milvina* treatments were not significantly different from each other. Proportion of spiderling dismounts among treatments for all other days was not statistically significantly different based on Tukey post-hoc comparisons.

Other studies of spiderling dispersal times among *Pardosa* species have found ranges of 2–7 days for *P. milvina* (Montgomery 1903), 4–8 days for *P. laura* (Karsch, 1879)(Fujii 1976), and 3–7 days for *P. t-insignita* (Bösenberg & Strand 1906)(Fujii 1976). None of these studies noted remounting behavior among spiderlings but dismounting and remounting for purposes of water seeking are known to occur among lycosids (Higashi & Rovner 1975). Since spiderlings were not marked, it was not possible to determine the frequency of remounting by individual spiders. We noted that mounted spiderlings would frequently crawl down one of the mother's legs and lightly tap at the ground. Afterwards they would either climb back onto the mother's dorsum, or dismount entirely. This behavior suggests a mechanism by which spiderlings may sample the substratum directly prior to dismounting. We also noted that dismounted spiderlings tended to remount their mother only after direct physical contact rather than showing directional orientation and approach toward the mother from other parts of the container. These observations indicate that remounting tends to be incidental with further maternal contact rather than a directed response from the spiderling at a distance.

The differences in spiderling dismounts between treatments were modest, yet there was a significantly smaller proportion dismounted from their

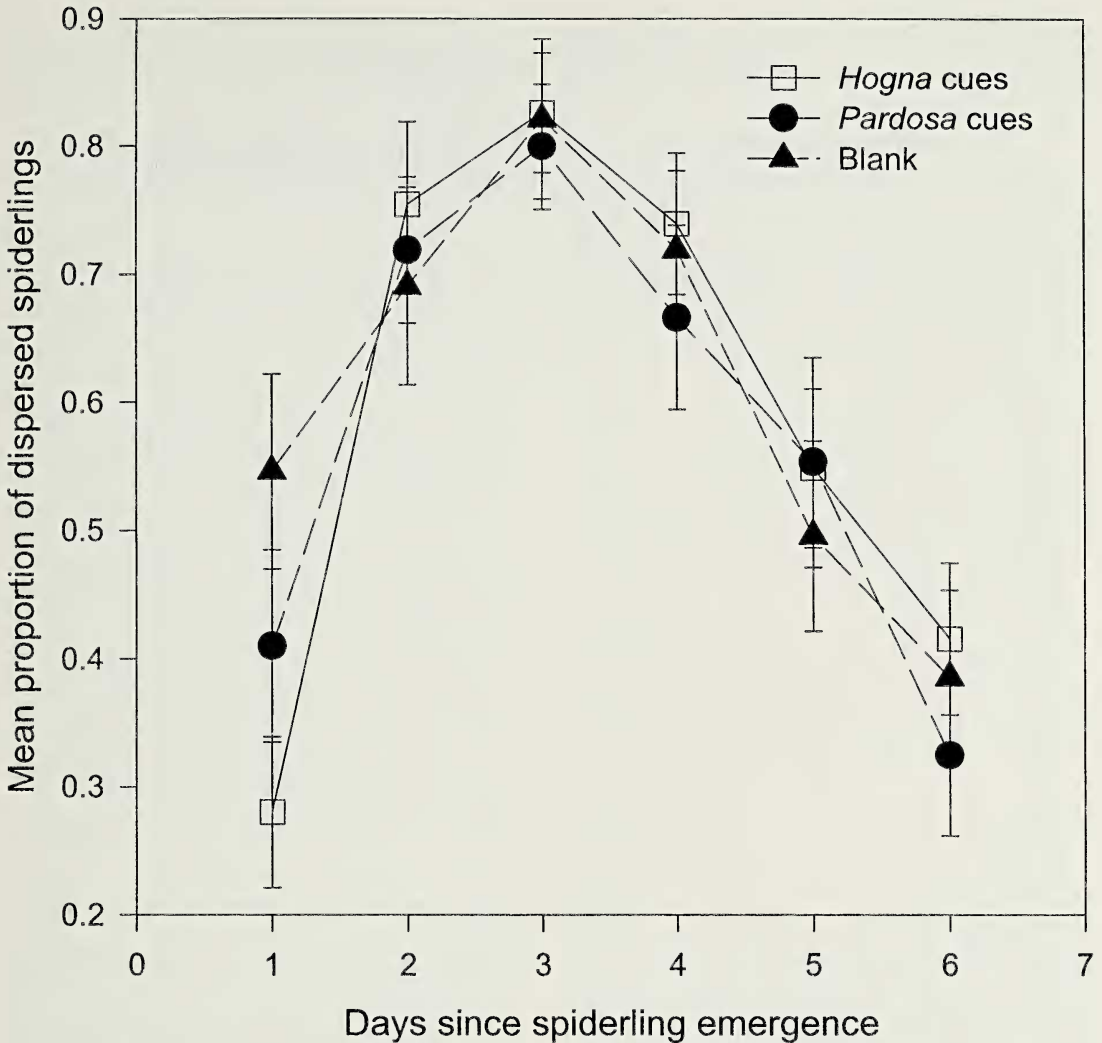


Figure.—Mean proportion of spiderlings dispersed from their mothers (\pm S.D.) while on substrates previously occupied by a conspecific female *P. milvina* for 24 h (*Pardosa* cues), a juvenile *H. helluo* (*Hogna* cues), or a control substrate not previously occupied (Blank).

mothers in the *H. helluo* treatment on day one of the experiment. In our study we did not renew the silk and excreta over the six-day experimental period. Previous studies indicate that *P. milvina* response to *H. helluo* cues becomes reduced over time due to the age of the stimulus (Barnes et al. 2002) rather than habituation to the cues (Persons et al. 2002). Adult females have a strong response toward fresh silk and excreta deposited by an adult *H. helluo* less than 24 hours earlier but are less responsive to one week-old *H. helluo* cues (Barnes et al. 2002). Results observed here are consistent with Barnes et al. (2002) in that the effect of *H. helluo* cues appeared to have diminished over the duration of the experiment and may have contrib-

uted to the significant response during the first day but not on subsequent days.

Given the high activity level of *P. milvina* (Walker et al. 1999), we propose that even small differences in spiderling dismount frequencies across treatments may translate into favorable non-random site dispersal with respect to the presence of *H. helluo*. For now it remains unclear the extent to which variation in spiderling dismounts are attributable to spiderlings directly responding to predator cues or indirectly via subtle changes in the mother's behavior in the presence of these cues. However, spiderling dispersal via other mechanisms should be considered as well. The prevalence of aerial ballooning or other forms of secondary dispersal in *P. milvina*

is unknown, but has been observed in other species in the genus (Richter 1970) and may further allow spiderling avoidance of areas with higher predation risk.

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